EVALUATION OF MUNICIPAL WASTE SOIL AND APPLICATION OF NPK FERTILIZER ON THE GROWTH AND YIELD OF OKRA AND GARDEN EGG

BY

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BENIN CITY

DECEMBER, 2025

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THESIS SUBMITTED TO SCHOOL OF POSTGRADUATE STUDIES IN
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DECEMBER, 2025

DECLARATION

I hereby declare that this Dissertation has been written by me and is a record of my own research work. It has not been presented in any previous application for a higher degree of this or any other University. All citations and sources of information are clearly acknowledged by means of references.

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Philip Obasogie Oviasogie

Date................................

CERTIFICATION

This is to certify that this research work was carried out by OVIASOGIE; Philip Obasogie under the guidance of the project supervisors and approved by the Department of Soil Science and Land Management, Faculty of Agriculture, University of Benin, Benin City, Nigeria.

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Prof. J.O.Ehigiator Date
(Supervisor)

______________________________ __________________

Dr. Mrs. V.I.O. Edosa Date
Head, Department of Soil Science
and Land Management

DEDICATION

This project is dedicated to God Almighty for the opportunity, grace, knowledge and sound mind through my years of study in the University of Benin, to my wife Prof. (Mrs.) F. E. Oviasogie and my children, Osasogie, Lovie (Udeme), Divine, Samuel and David for their prayers and support throughout the programme. May the name of God be praised and glorified both now and forever.

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ABSTRACT

The present study evaluated the physical, chemical, and heavy metals content (Fe, Zn, Mn, and Cu) and fertility status of soils from three dumpsites within the Benin city metropolis and the effect of NPK (15:15:15) fertilizer on the growth and yield of Okra and Garden Egg. Soils samples were collected processed and analyzed using standard laboratory methods. The experiment was a 3 x 4 factorial fitted in a Completely Randomized Design (CRD), with three levels of fertilizer (0 g NPK, 14 g NPK and 28 g NPK) and (3) dumpsites (Benin Sapele Road Dumpsite (BSD), Benin Agbor Road Dumpsite (BAD) and Benin Oluku Bypass Dumpsite (BOD) and the control with three replications. Growth parameters (plant height, number of leaves; stem girth; leaf area) and yield were collected. The fruit yield per hectare was derived by estimating the fruit yield per poly bag. Data were subjected to Analysis of Variance (ANOVA), and treatment means were separated using Duncan's Multiple Range Test at 5% probability level. Results showed that, physical and chemical properties of the dumpsite soils were slightly alkaline with pH range of 7.28 to 7.56. The organic carbon ranged between 11.6 and 13.7 g/kg. The fertility status of the soils from the different dumpsites revealed that soils from Agbor Road ByePass were high in potassium while soils from Oluku and Sapele ByePass dumpsites were high in phosphorus and nitrogen. The total N from the dumpsites ranged between 0.065 to 0.199 %. The heavy metal content of dumpsite soils varied significantly, but was within the limits recommended by FAO/WHO. The application of 28 g NPK fertilizer enhanced the growth and yield of Okra and Garden Egg compared to the control. This study suggest that dumpsite soils amended with NPK fertilizer improved soil nutrients status and enhanced the yield and growth of Okra and Garden Egg plant.

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ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
AAS	Atomic Absorption Spectrometer
BAD	Benin Agbor Dumpsite
BADC	Benin Agbor Dumpsite Control
BOD	Benin Oluku Dumpsite
BODA	Benin Oluku Dumpsite Control
BSD	Benin Sapele Dumpsite
BSDC	Benin Sapele Dumpsite Control
DMRT	Duncan Multiple Range Test
Ca	Calcium
CEC	Cation Exchange Capacity
CRD	Completely Randomized Design
Cm	Centimeters
Cm^2	Centimeters square
Cr	Chromium
Cu	Copper
EC	Electrical conductivity
Fe	Iron
K	Potassium
L A	Leaf area
Mn	Manganese
NIFOR	Nigerian Institute for Oil Palm Research
NIHORT	National Institute for Horticultural Research Ibadan
NL	Number of leaves
NPK	Nitrogen, Phosphorus and Potassium
P H	Plant height
RCBD	Randomized complete block design
SG	Stem girth
Zn	Zinc
WAT	Weeks after Treatment application

CHAPTER ONE

1.0 INTRODUCTION

A global hunger crisis was forecasted to hit the world in 2023 by Chilkoti (2022). As many as 50 million people would have entered 2023 on the brink of famine, and with governments still reeling from the covid-19 pandemic and grappling with slowing economic growth; many of those people could be starving in the coming months (Chilkoti, 2022). Until now, the problem has largely been spiraling prices rather than availability. Considering all people in the world affected by moderate levels of food insufficiency together with those who suffer from hunger, it is estimated that over 2 billion people do not have regular access to safe, nutritious and sufficient food. One of the strategies that have been suggested in curbing food insecurity is urban agriculture. Urban agriculture (UA) is defined as the production of crop and livestock goods within cities and towns. According to some accounts, 200 million people are employed in urban farming and related enterprises, contributing to the food supply of 800 million urban dwellers (Smit *et al.*, 1996). Analyzing the extent to which urban agriculture might help shield the urban poor from some of these shocks becomes a topical policy question. While soil pollution traditionally has not received attention as issues like tree-planting, global momentum picked up in 2018 when the Food and Agricultural Organisation of the United Nations (FAO) published a ground breaking study: soil pollution; a hidden reality. The report found that the main anthropogenic sources of soil pollution are the chemicals used in or products/by-products of industrial activities; domestic, livestock and municipal wastes (including wastewater); agrochemicals; and petroleum-derived products. These chemicals are released to the environment accidentally, for example, from soil spills or leaching from landfills, or intentionally, through use of fertilizers and pesticides, irrigation with untreated wastewater or land application of sewage. It is important to state herein that the use of municipal waste dump soils plays a vital role in Urban Agriculture Crop Production systems.

1.1. JUSTIFICATION

Soils obtained from refuse dumpsites and used in the cultivation of crops could have varied fertility status and significant content of heavy metals which may have adverse effect on crop productivity and safe consumption (Rashid *et al*., 2023). Therefore, there is need to screen or determine the quality of soils obtained from refuse dumpsite for crop production.

1.2 Objectives of the study

The present study seeks to:

1. Determine the physical and chemical and heavy metals content of soils from selected waste dump sites in Benin City metropolis
2. Evaluate the fertility status of the soils from different dumpsites in Benin City
3. Determine the effects of dumpsites soils amended with fertilizer on the growth and yields of Okra and Garden egg.

CHAPTER TWO

2.0 LITERATURE REVIEW

Increase in human population has led to high demand in food and other agricultural products such that farmers have resulted to the use of solid waste as composts for amendment of degraded soils for improved fertility and productivity for agricultural sustainability. The intensification of the industrial process and the rapid population growth and the consequent demand for consumer goods has provoked an increase in the volume of wastes generated. There is therefore, a concern on global scale, to solve the problem of waste generation and disposal in the environment (Cayumil, 2021). Globally millions of tons of wastes are generated which must be collected and disposed of appropriately. In China, India, and other countries, such as Turkey, Mexico, and Brazil, almost 90% of the solid wastes that are composed mainly of the organic fractions are usually sent to landfills as garbage dumps. Besides the significant increase in the generation of these wastes, in recent years, there have been significant changes in their composition and characteristics and increased hazardousness (WHO, 2007). Dumping of such waste produce leachate, that causes soil and ground water contamination (Isidori *et al*., 2003; Ande and Onajobi, 2009, Chukwudi *et al*., 2017).

Generally, Municipal solid waste contain a considerable proportion of plastic, paper, metal rubbish and batteries and is considered to be the source of heavy metals contamination. In fact, most heavy metals pollution in soils is associated with the massive dumping of solid wastes. In most developing countries like Nigeria, the use of waste dump as an ideal system of waste management and disposal is a common practice (Achudume and Olawale, 2007). It is important to note that the soil is a principal recipient of solid waste. These wastes interact with the soil system thus altering the physical and chemical properties (Piccolo and Mbagwu, 1997). A number of significant impact of solid wastes in soils have been conducted previously, including rise in nitrogen, pH, cation exchange capacity, percentage base saturation and organic matter

(Anikwe and Nwobodo, 2001). According to Anikwe (2000), waste amended soils have high content of organic matter. The soil organic matter influences the degree of aggregation and aggregate stability (Mbagwu and Piccolo, 1990). It has been documented in literature that heavy metals may have harmful effects on soils, crops and human health (Smith *et al.*, 1996). However, research has shown that applying these wastes to the soil may cause environmental problems due to the addition of excess N, pathogens, heavy metals (Obasi *et al.*, 2012), acidification (Obianefo *et al.*, 2017), and salinization of agricultural soils (Okonkwo *et al.*, 2013). The implication associated with heavy metal contamination is of great concern, particularly in agricultural production systems. These metals can pose a significant health risk to humans, particularly in elevated concentrations above the low body requirements (Gupta and Gupta, 1988). Heavy metals in general are not biodegradable and long biological half-lives have the potential for accumulation in the different body organs leading to unwanted side effects (Sathawara *et al.*, 2004.). They ranked high amongst the chief contaminants of leafy vegetables (Mapanda *et al.*, 2005). Among the heavy metals, copper (Cu) is an essential element but excess exposure can cause hepatic and kidney damage, haemolytic anaemia and methanoglobinemia. Increased levels of cadmium exert detrimental effects on human health and causes severe diseases such as tubular growth, kidney damage, cancer, diarrhea and incurable vomiting. The concentration of lead if exceeding the maximum permissible limits in human affects nervous system, bones, liver, pancreases, teeth and gum and also causes blood diseases. Various studies have been conducted to evaluate the heavy metal uptake by plants in relation to soil pollution and atmospheric deposition on the surface of soils [Haghiri (1974); Institute for Soil Fertility (1988); Muller and Anke (1994); Ward and Savage (1994)]. Larsen *et al.* (1992) found elevated concentrations of Cr and As in soils and plants around a wood preservation factory in Denmark. Around a Cadmium (Cd) processing factory in Germany, very high Cd levels were found in soils and in the banks of the Grumbach brook, which resulted in very high Cd levels in lettuce, onions, and parsley that exceeded the limit values. Therefore, food crops grown on these polluted soils may be affected by these pollutants because soil is difficult and expensive to cleanup (Alloway and Ayres, 1997).

2. 1 Impact of Municipal Waste Dumpsite on Soil Properties

The impact of wastes on properties of soil around municipal waste dumpsite has been documented in scientific literature. Recent studies on the impact of wastes on soil properties around a particular dumpsite in Ibadan, Southwestern Nigeria by Akintola *et al*. (2021) reported that the deposition and decomposition of wastes led to significant impact on soil pH, bulk density, moisture content, porosity, electrical conductivity**,** exchangeable bases and heavy metals (Fe, Zn, Pb, Cu, and Ni). However, no remarkable impact was noticed on the texture of the soils. The high pH values and organic matter content in the dumpsite soils had increased nutrient contents such as exchangeable based and micronutrients, thus enhancing soil microbial activities, fertility and productivity status of the soil for maximum plant growth. Dumping such waste had increased the soil moisture, pH, EC, TDS, volatile solids, organic carbon and heavy metals concentration. The study suggested that the huge quantity of biodegradable waste which is generated in the city could be effectively managed by using these materials for energy or compost (bio-fertilizer) production. Agbeshie *et al*. (2020) evaluated the impact of Municipal waste dumpsite on soil properties and heavy metal concentrations in Sunyani, Ohana soils and revealed that mean soil pH of the dumpsite ranged from 6.5 -7.5, which is optimum for microbial activities and nutrient uptake. Higher content of N.P.K, Mg recorded was as a result of the disposal of household and agricultural wastes at the dumpsite. The high nutrient content at the dumpsite location especially the organic carbon and exchangeable bases significantly impacted on soil bulk density, porosity and nutrient availability at the dumpsite. Generally, the concentration of heavy metals ranked as Fe> Pb> As> Zn> Cd.

Oviasogie *et al.* (2007) showed that the refuse dumped at the various sites in Akure had detectable and measurable changes on the soil qualities. The refuse contributed to increase amounts of the metals investigated especially Pb and Cd. Ukpebor *et al*. (2003), which evaluated the distribution of some heavy metals around two major refuse dumpsites in Benin City, Nigeria showed no serious environmental concerns as at the time of the report, thus recommending the use of the dump soil for agricultural purposes. Oviasogie and Oviasogie (2015) investigated the physical and chemical properties and fungal dynamics of soil obtained from public and residential waste dumpsite in Benin City and environs. The study showed that available phosphorus, total organic carbon, and total nitrogen was highest in the waste dump soils obtained from the residential area. These wastes contained mainly biodegradable substance which was reflected in the higher population of fungi. Sam-Uruopa and Ogbeiba (2020) assessed the effect of solid waste disposal on the receiving soil quality in Benin metropolis, Nigeria. The results of the study showed that the soils can be considered to be impacted, slightly polluted with respect to the heavy metals except for cadmium by the presence of the waste dumpsites. The study further revealed that the cation exchange capacity (CEC) of the soils from the dumpsites were all higher than the control station soils. This finding indicated that there was more organic matter decomposition in the soil as a result of the waste and thus had nutrients more than the control.

2. 2 Heavy Metals in Soil

Heavy metals are naturally occurring elements with relatively high atomic weight and density that may become toxic at elevated concentrations. The term commonly refers to elements such as cadmium (Cd), lead (Pb), chromium (Cr), nickel (Ni), zinc (Zn), copper (Cu), mercury (Hg), and arsenic (As). While some of these metals (e.g., Zn, Cu, Ni) are essential micronutrients for plants and microorganisms, others (e.g., Cd, Hg, Pb) have no known biological function and are toxic even at low concentrations (Alloway, 1990; Goyer and Clarkson, 1996).

Soils act as both sinks and sources of heavy metals. They accumulate metals from natural processes and anthropogenic inputs and may later release them into plants, groundwater, or the atmosphere depending on prevailing environmental conditions.

2.2.1. Sources of Heavy Metals in Soil

Heavy metals originate naturally from weathering of parent materials, volcanic emissions, atmospheric deposition, and natural forest fires. Similarly, the geological composition of the parent rock strongly influences background metal concentrations (Brady and Weil, 2016). For example, soils derived from shale often contain higher concentrations of Cd and Zn than those formed from sandstone.

Furthermore, human activities such as application of sewage sludge and wastewater irrigation, use of phosphate fertilizers and pesticides, industrial emissions and mining activities, municipal solid waste disposal, and automobile emissions and fossil fuel combustion significantly elevate heavy metal levels in soils. Long-term sludge application and waste disposal have been shown to increase soil metal concentrations substantially (Mapanda *et al.*, 2005; Kirchmann *et al.*, 2014). These inputs often alter not only total metal concentrations but also their chemical forms and bioavailability.

2.2.2. Forms of Heavy Metals in Soil

Heavy metals do not exist as free elements in soil. They occur in various chemical forms (speciation), which determine their mobility and bioavailability. The exchangeable fraction are weakly adsorbed on soil colloids and are easily available whereas the carbonate-bound fraction are associated with carbonates and sensitive to pH changes. The Fe-Mn oxide-bound fraction are adsorbed or co-precipitated with oxides while the organic matter-bound fraction are complexed with humic substances. Lastly, the residual fraction are incorporated into mineral lattices and are the least available. The exchangeable and carbonate-bound forms are generally considered the most bioavailable and environmentally mobile (Alloway, 1995).

2.2.3. Behavior of Heavy Metals in Soil

The behavior of heavy metals in soil is controlled by several physical and chemical factors including pH, organic matter, clay minerals, cation exchange capacity, redox potential, and precipitation and dissolution processes.

Under acidic conditions, metals such as Cd^{2+}, Pb^{2+}, and Zn^{2+} become more soluble and more available for plant uptake (Brady and Weil, 2016). Conversely, liming acidic soils can significantly reduce metal bioavailability. On the other hand, humic and fulvic acids bind metals, reducing their free ionic activity (Piccolo and Mbagwu, 1997). However, soluble organic ligands may also enhance metal mobility by forming soluble complexes. Metals such as Cu and Pb show strong affinity for clay surfaces and Fe-Mn oxides, whereas Cd is more weakly adsorbed and therefore more mobile.

Under reducing conditions (e.g., waterlogged soils), Fe^{3+} and Mn^{4+} oxides dissolve, potentially releasing adsorbed metals whereas chromium may shift from Cr^{3+} (less toxic) to Cr^{6+} (highly toxic) depending on oxidation state. Similarly, heavy metals may precipitate as hydroxides (e.g., $Pb(OH)_2$), carbonates (e.g., $CdCO_3$), and sulfides (e.g., PbS under anaerobic conditions). These processes reduce mobility, but changes in pH or redox conditions may cause dissolution and remobilization.

2.2.4. Interactions of Heavy Metals in Soil

Heavy metals interact with soil components and with each other through several mechanisms including adsorption–desorption reactions, competition and antagonism, complexation with organic ligands, and interaction with soil microorganisms.

Metals such as Cr, Pb, and As attach to soil particle surfaces via electrostatic attraction, specific adsorption, and surface complexation. Desorption can occur when environmental conditions change (e.g., pH reduction), increasing environmental risk. Zn may compete with Cd for adsorption sites and plant uptake pathways while Ca and Mg may reduce Pb uptake, influencing plant nutrition and toxicity.

Organic acids, root exudates, and microbial metabolites also form soluble metal complexes, influencing. Mobility, bioavailability, and plant uptake. Microbial biomass also temporarily immobilizes metals through intracellular accumulation (Brookes *et al.*, 1985). Essential metals such as Zn and Cu support enzyme function at low levels whereas toxic metals such as Cd, and Hg inhibit enzyme systems and reduce microbial biomass. Microbial resistance mechanisms include metal sequestration, efflux systems, and enzymatic detoxification (Bruins *et al.*, 2000).

2.2.5. Plant Uptake and Bioavailability

Plants absorb metals primarily as free ions or soluble complexes. Excess accumulation may lead to phytotoxicity, reduced growth, and entry into the food chain, posing health risks to humans and livestock (Goyer and Clarkson, 1996). Heavy metal accumulation in agricultural products is not only associated with the total metal concentration in soil but also strongly dependent on the uptake mechanisms, soil physical and chemical properties, chemical speciation of metals, soil texture, nature and quantity of nutrients, climate and other factors. (Peijnenburg *et al.*, 2007). The availability of heavy metals such as copper (Cu), Nickel (Ni) and lead (Pb) in soil is significantly related to crop uptake of metals (Zhang *et al.*, 2018). Heavy metal transfer from soils to plants is directly correlated with the available metal concentration in soils. Human Health may be affected by heavy metal through the soil-plant-human pathway. Therefore, heavy metal availability plays an important role in the evaluation of phytoextraction.

2.3 Environmental Risk and Public Health

Wastes as a source of plant nutrients have been used in some countries for decades (Kirchman *et al*., 2014; Charlton *et al*., 2016, Vieira and Pazianotto, 2016). However, research has shown that applying these wastes to the soil may cause environmental problems due to the addition of excess nitrogen, pathogens, heavy metals (Rattan *et al*., 2005; Stott and Carter, 2008), acidification (Raveh and Ben-Gal, 2016) and salinization of Agricultural soils (Liu *et al*., 2014). Heavy metals are elements with atomic number greater than 20, and a density greater than 5gcm^3 group includes any element that could damage the plant and animal organisms, including metalloids and semi-metals such as Selenium and Arsenic (Alloway, 1995). All these elements have high reactivity and under normal conditions are traces in the mineralogical composition of soils (Alloway, 1995). Heavy metals have important functions in the biosphere, acting as essential micronutrients for plants (Cu, Fe, Mg and Zn), or as beneficial (Mo and possibly Ni) to microorganisms(Co and Mo to genus Rhizobium and bacteria) and to animals (Co, Cr, Mo, Cu, Se, and Zn) (Bruins *et al*., 2000). However, when these elements are found at high concentrations, they are toxic to superior organizations, just like no nutritional elements or without biological effects, such as Cd, Pb, and As. All heavy metals are toxic to the biological systems. The level of risk is a function of the quantity of contaminant and the time the organism is exposed to it (Goyer and Clarkson, 1996).

2.4 Okra

Okra (*Abelmoschus esculentus*) is an annual, herbaceous flowering plant in the Mallow family that originated from tropical and subtropical Africa and is natural to West Africa (Aladele *et al*., 2008). Okra is mainly cultivated for its young immature fruits and consumed as a vegetable, raw, cooked or fried in countries like Sudan, Egypt and Nigeria. It is often used as ingredient of soups and sauces in most countries of the world. The fruits can be conserved by drying or pickling; the leaves, flower buds, flowers and calyces can be cooked and eaten as greens (Raji *et al*., 2009). In Nigeria, Okra is grown in both wet and dry season but attract a larger profit in the dry season when the demand is often in excess with limited supplies (Alamu and Olushola, 2017). Okra is a good source of vitamins, minerals, calories and amino acid found in seeds and compares favorably with those in poultry, eggs and soybean (Brady and Weil, 2016). Okra cultivation requires nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sodium (Na) and Sulphur (S) for fertility maintenance and crop production. These nutrients are specific in function and must be supplied to plants at the right time and at the right quantity. Lack of sufficient amounts of these nutrients result in poor performance of the okra with growth been affected resulting to low yield (Chauhan, 1972). However, municipal waste dump soils are rich in nutrients and it is a productive use of urban waste for agriculture.

Various researches have affirmed the cholesterols' ability of Okra seeds (Gemede *et al*., 2015). The quantity of oil depends on seed variety, climate conditions, and temperature and extraction method. Okra seed oil plays crucial role in maintenance of lipid profile in the body. Okra is gaining importance due to its therapeutic activities and also known as a functional food owing to its pharmacological properties mainly anti-diabetic, anti-hyper cholesterol and anti-obesity activities (Khan and Faiz, 2021).

2.5 Garden Egg

The name "Garden egg plant" was derived from the shape of the fruits, some varieties which are white in shape like chicken eggs (Daunay *et al*., 2001). The plant (Solanum spp) is a vegetable with increasing popularity in the world (Pessarakli and Dris, 2003). It originated from Tropical Africa (Norman, 1992). It is an economic flowering plant belonging to the family Solanaceae. About 1,400 species are found throughout the temperate and tropical regions of the world are mostly herbaceous plants. The fruit of the plant comes in a wide array of shapes and colours, some are yellow and small with green stripes. there are the big yellow ones with white colour and flat ribbed green types among others (Daunay *et al*., 2001).

The importance of the garden egg cannot be over emphasized. It is consumed on daily basis by urban families and also represents the main source of income for producing households in West Africa (Schippers, 2000). Nutritionally, garden egg contains 92.5% water, 1% protein, 0.3% fat, and 6% carbohydrates. They contain between 30 and 50% of iron (Fe), fiber, potassium (K), manganese (Mn), copper (Cu) and vitamins; thiamin (vitamin B1), B6, folate, magnesiumand niacin. Garden egg also contains phyto-nutrients such as nasunin and chlorogenic acid (USDA, 2019). It is a very good source of dietary fiber, potassium, manganese, copper and vitamin B6, folate, magnesium and niacin. Egg plant also contains phyto-nutrients such as nasunin and chlorogenic acid. It is a valuable vegetable for canning industries for garden-egg pastesautéed garden-egg and other products (Raigón *et al*., 2008). The fruits are fried, stewed, marinated and prepared in other ways. The garden egg-plant with its bitter taste and spongy texture could really make an amazing pot of stew with a nice aroma. Medicinally, they are processed and used in the preparation of condiments and products used in treating different diseases and health problems (Burkill, 1985). A meal of garden egg is proven to be of benefits to patients suffering from raised intraocular pressure (glaucoma) and convergence insufficiency, as well as in heart diseases and Arteriosccerosis (Noda *et al*., 2000).

Garden egg is often described as a “brain-supportive” food due to the presence of anthocyanin phytonutrients concentrated in its skin. One of the most studied of these compounds is nasunin, a potent antioxidant and free radical scavenger. Nasunin has been shown to protect cellular membranes, particularly the lipid components of brain cell membranes, from oxidative damage (Noda et al., 2000; Sedeek et al., 2019). Since neuronal membranes are rich in polyunsaturated fatty acids that are highly susceptible to peroxidation, the antioxidant activity of nasunin is considered especially important for maintaining neurological integrity.

Beyond its antioxidant capacity, nasunin also functions as an iron chelator. Iron is an essential micronutrient required for oxygen transport, immune function, and collagen synthesis; however, excess free iron in biological systems can catalyze the formation of reactive oxygen species through Fenton reactions, thereby increasing oxidative stress (Goyer and Clarkson, 1996). Elevated body iron stores have been associated with increased risks of cardiovascular disease and certain cancers. While menstruating women generally regulate iron levels through menstrual blood loss, post-menopausal women and men may accumulate excess iron because the body lacks an efficient excretory mechanism for iron. By chelating free iron, nasunin reduces iron-induced free radical formation, thereby protecting low-density lipoprotein (LDL) cholesterol from peroxidation and limiting oxidative cellular damage linked to carcinogenesis and inflammatory disorders such as rheumatoid arthritis (Noda *et al.*, 2000).

In addition to nasunin, garden egg contains significant amounts of chlorogenic acid, the predominant phenolic compound in the fruit. Chlorogenic acid is recognized as one of the most effective free radical scavengers in plant tissues and exhibits strong antimutagenic and anticancer properties (Sedeek *et al.*, 2019). It has also been reported to exert hypolipidemic effects by reducing low-density lipoprotein (LDL) considered as bad cholesterol while supporting higher levels of high-density lipoprotein (HDL) considered to be good cholesterol. Furthermore, chlorogenic acid demonstrates antiviral and antimicrobial activities, contributing to the plant’s protective health profile.

Consumption of garden egg has also been associated with benefits in ocular health, particularly in reducing intraocular pressure in individuals with glaucoma, although more clinical evidence is required to substantiate this claim fully (Ma and Lin, 2010). Nutritionally, garden egg is low in calories and high in dietary fibre, making it suitable for weight management and carbohydrate-controlled diets (Obeng-Ofori, 2007; USDA, 2019). Its fibre content supports digestive health and contributes to satiety, making it a suitable snack option between meals.

However, garden egg plant contains measurable amounts of oxalates, naturally occurring compounds found in many plant foods. When oxalates accumulate excessively in body fluids, they may crystallize and contribute to kidney or gallbladder stone formation. Individuals with pre-existing and untreated kidney or gallbladder disorders may therefore need to moderate intake. Nevertheless, for most healthy individuals, consuming garden egg as part of a balanced diet does not interfere significantly with calcium absorption, particularly when foods are properly chewed and combined with calcium-rich sources.

Globally, production of garden egg is highly concentrated, with approximately 85% of global output originating from five major producing countries, reflecting its agricultural and economic significance in tropical and subtropical regions (FAO, 2022). Presently, China is the world largest producer (56% of garden-egg output), followed by India (26%), Egypt, Turkey and Indonesia. Meanwhile, more than 2,048,788 ha are devoted to cultivation of garden egg (FAO, 2008). In the United State of America, Georgia is the largest producing State. African garden-egg is one of the most commonly consumed fruit vegetable in the Tropical Africa, in quantity and value and probably, the third after Lycopersicum esculentum (tomato) and Alum cepa (onions) and before Okra. According to FAO (2008), a rough estimate for a few countries indicates an annual production of 8,000 tonnes in Senegal, 60,000 tonnes in Cote d’ Ivoire and 4,500 tonnes in Burkina Faso. In Nigeria, garden egg is a very important vegetable crop grown on commercial scale in some parts of the country. However, the small-scale growers account for at least 86% of the total production. In the South -East of Nigeria, specifically, in Abia State, garden-egg popularly called “Mikimiki “ (big sized green fruit with very deep and sweet “endocarp”) is grown commercially while in the savannah zone of Nigeria; the yellow, white and thick green skinned varieties are grown on large scale. Garden-egg production in Giri, Gwagwalada Area Council, Abuja, Nigeria, seems to be a lucrative venture for the peasant farmers. Production has been all year round and even unable to meet the market demand for the products. Quite a number of varietiesof garden egg fruits are being sold in this area both in retail and whole sale. Unfortunately, there has been little or no information on the production of the crop in the study area.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the study

The study was carried out in Benin City metropolis. Soils were collected from three (3). Government designated waste dumpsites in Benin City and the environs between February to March, 2023 in Benin Sapele Road Dumpsite 06° 17' 39.28''N and 005° 32' 45.78''E, Benin Agbor Road Dumpsite (06° 18' 40.6''N and 005° 38'13.8''E and Benin Oluku Bypass Dumpsite 06°19' 39.3''N and 005°44' 45.9''E, Edo State, Nigeria. The study area falls within the rainforest zone of Nigeria. Humid tropical climate prevails with average annual rainfall of 2000 - 2500 mm (Ogeh and Adeoye, 2012). In the raining season, the rainfall pattern is bimodal and falls between April and October, while the dry season is between November and April. The mean air temperatures ranged between 22 ºC and 31° C. Municipal trash has been dumped at the three locations for over twenty years.

3.2 Geology and soils

The soils of the study area are derived from sedimentary material of unconsolidated coarse textured sandstones. The soils in the study area consists of four distinct regions in terms of geological formation and parent material, namely the Niger Delta coast line, the Benin lowlands, the Afemai uplands and the lower Niger valley. Benin formation (Kogbe, 1976) is referred to as the Benin formation of Miocene-Pleistocene alluvial deposits of Nigeria and its tributaries is classified as Rhodic kandiudults (USDA) (Okunsebor et al., 2024).

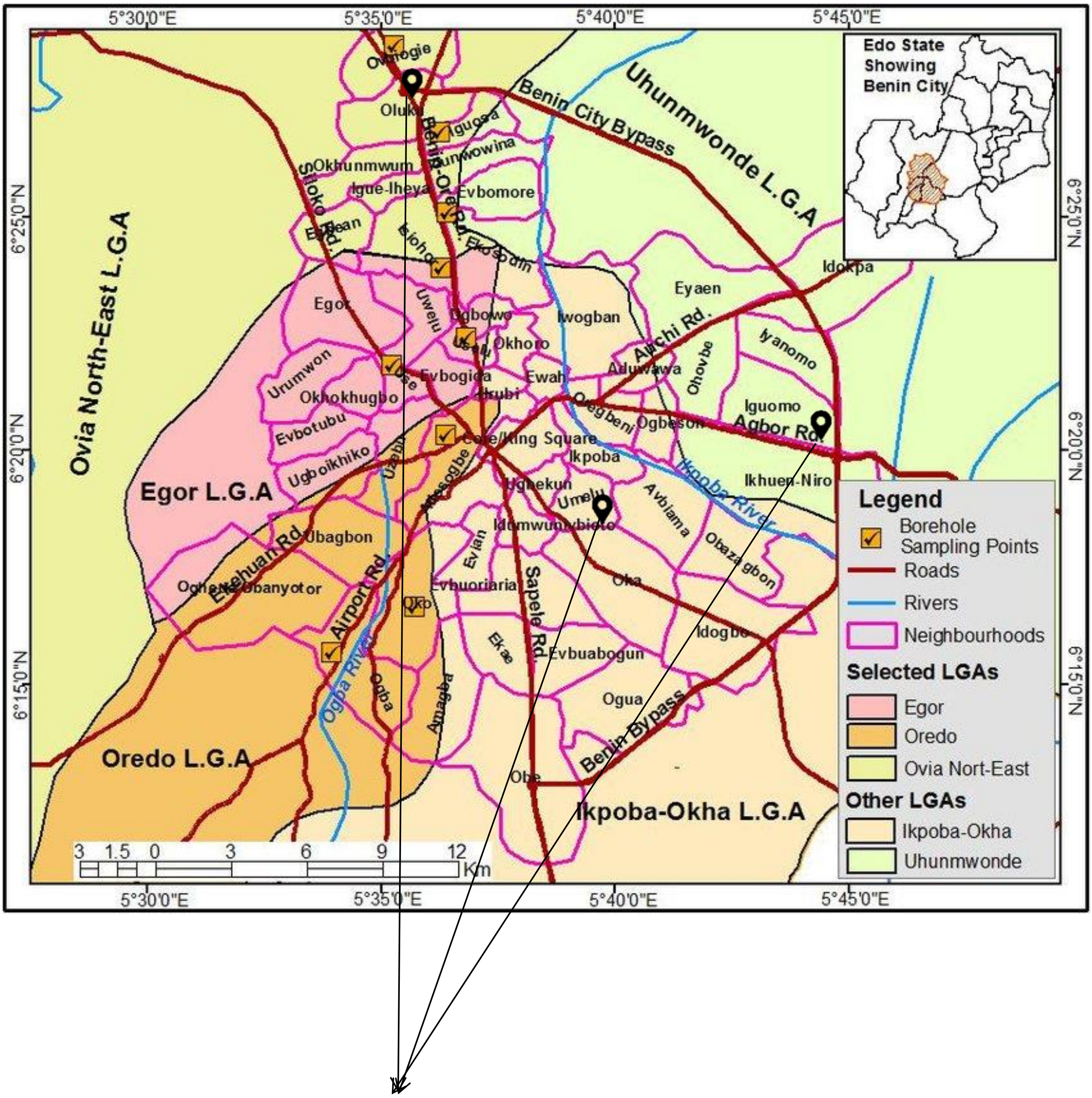

Figure 1: Map Showing Soil Collection Sites from Dumpsite in Benin City and Environs

3.3.1 Soil Sample Collection and Analyses

Soils were collected with the aid of a spade from the various waste dumpsites represented in Figure 1. The collected soils were placed in 50 kg bags labeled accordingly and taken to the laboratory for processing and analyses.

3.3.2. Soil Analyses (physical and chemical properties)

Soil samples were randomly taken from the three waste dumpsites each with a control taken at a distance of 200m away from the dumpsite with the aid of soil auger, bulked, air dried and ground to pass through a 2mm sieve. Soil analysis was carried out using the method of Okalebo (2002). Particle size distribution was determined by hydrometer method (Gee and Or, 2002). Soil pH was determined in 1:2 soil water suspensions using a pH meter (Hendershot *et al*., 1993) Organic carbon was analyzed by the dichromate oxidation procedures (Walkley and Black, 1934) method and converted to organic matter by multiplying with 1.724. Total nitrogen was determined by Micro-kjeldah method (Brookes *et al*., 1985). Available phosphorus was determined by Bray-1 method (Bray and Kurtz, 1945). Exchangeable cations were extracted using NH_4OAC buffered at pH 7.0 (Thomas, 1982), Potassium (K) and Sodium (Na) were determined with a flame photometer while Exchangeable calcium (Ca) and Magnesium (Mg) were determined using Atomic Absorption Spectrophotometer (AAS) Perkin Elmer 403.

3.3.3 Determination of Heavy Metals

The 10.0 g of air-dried soil was weighed into a plastic container and 50 ml of 0.1MHcl was added to it. The mixture was agitated on a mechanical shaker for one hour and then filtered through a whatman No.42 filter paper (Sutherland and Tack, 2008). The filtrate from the extraction was analyzed for Fe, Cu, Mn, Zn, Cr, Cd, and Pb using Atomic Absorption Spectrometer.

3.4 Experimental Design and Treatments

Treatments consisted of 2 factors namely; Factor A: NPK fertilizer, at three (3) levels: 0 g NPK, 14 g NPK and 28 g NPK equivalent to 0 t/ha NPK, 5.6 t/ha NPK, and 11.2 t/ha respectively. Factor B: soils collected from three different dumpsites namely: Benin-Agbor Dumpsite (BAD), Benin-Sapele Dumpsite (BSD), Benin-Oluku Dumpsites (BOD), and the control from each location. The experiment was a 3 x 4 factorial design with three (3) replicates fitted to a Completely Randomized Design (CRD) to give a total of 12 treatments combinations; Treatments were assigned randomly using the balloting method as shown in Table 1.

Okra crop

T_1 = BADC + OK

T_2 = BAD + 0 g NPK + OK
T_3 = BAD + 14 g NPK + OK
T_4 = BAD+ 28 g NPK + OK
T_5 = BSDC + OK
T_6 = BSD + 0 g NPK + OK
T_7 = BSD + 14 g NPK + OK
T_8 = BSD + 28 g NPK +OK
T_9 = BODC+ OK
T_{10} = BOD + 0 g NPK + OK
T_{11} = BOD + 14g NPK + OK
T_{12} = BOD + 28gNPKMg + OK

Key: BAD = Benin-Asaba Dumpsite, BADC = Benin-Asaba Dumpsite Control, BSD = Benin-Sapele Dumpsite, BSDC = Benin-Sapele Dumpsite Control, BOD = Benin-Oluku Dumpsite, BODC = Benin-Oluku Dumpsite Control, OK = Okra, NPK = Nitrogen, Phosphorus, and Potasium.

Note:
0 g NPK in 5 kg pot = 0 t/ha
14 g NPK in 5 kg pot = 5.6 t/ha
28 g NPK in 5 kg pot = 11.2 t/ha

Table 3.1: Screen House Layout for Okra

REP I	REP II	REP III
T_1	T_9	T_3
T_2	T_3	T_{12}
T_3	T_{10}	T_2
T_4	T_1	T_5
T_5	T_6	T_8
T_6	T_{12}	T_1
T_7	T_4	T_{11}
T_8	T_{11}	T_6
T_9	T_7	T_9
T_{10}	T_8	T_4
T_{11}	T_5	T_7
T_{12}	T_2	T_{10}

KEY:T_1 = BADC + GE, T_2 = BAD + 0 g NPK + GE, T_3 = BAD + 14 g NPK + GE, T_4 = BAD + 28 g NPK + GE, T_5 = BSDC + GE, T_6 = BSD + GE, T_7 = BSD + 14 g NPK + GE, T_8 = BSD + 28 g NPK +GE, T_9 = BODC+ GE, T_{10} = BOD + GE, T_{11} = BOD + 14g NPK + GE, T_{12} = BOD + 28gNPKMg + GE

Garden Egg

T_1 = BADC + GE

T_2 = BAD + 0 g NPK + GE

T_3 = BAD + 14 g NPK + GE

T_4 = BAD + 28 g NPK + GE

T_5 = BSDC + GE

T_6 = BSD +0 g NPK + GE

T_7 = BSD + 14 g NPK + GE

T_8 = BSD + 28 g NPK +GE

T_9 = BODC+ GE

T_{10} = BOD + 0 g NPK + GE

T_{11} = BOD + 14g NPK + GE

T_{12} = BOD + 28gNPKMg + GE

Key: BAD = Benin-Asaba Dumpsite, BADC = Benin-Asaba Dumpsite Control, BSD=Benin-Sapele Dumpsite, BSDC = Benin-Sapele Dumpsite Control, BOD = Benin-Oluku Dumpsite, BODC = Benin-Oluku Dumpsite Control, GE = Garden Egg, NPK = Nitrogen, Phosphorus, and Potasium.

Note:

0 g NPK in 5 kg pot = 0 t/ha

14 g NPK in 5 kg pot = 5.6 t/ha

28 g NPK in 5 kg pot = 11.2 t/ha

Table 3.2: Screen House Layout for Garden Egg

REP I	REP II	REP III
T_1	T_9	T_5
T_2	T_3	T_{12}
T_3	T_{10}	T_2
T_4	T_7	T_3
T_5	T_6	T_8
T_6	T_{12}	T_1
T_7	T_4	T_{11}
T_8	T_{11}	T_6
T_9	T_1	T_9
T_{10}	T_8	T_4
T_{11}	T_5	T_7
T_{12}	T_2	T_{10}

KEY:T_1 = BADC + GE, T_2 = BAD + 0 g NPK + GE, T_3 = BAD + 14 g NPK + GE, T_4 = BAD + 28 g NPK + GE, T_5 = BSDC + GE, T_6 = BSD + GE, T_7 = BSD + 14 g NPK + GE, T_8 = BSD + 28 g NPK +GE, T_9 = BODC+ GE, T_{10} = BOD + GE, T_{11} = BOD + 14g NPK + GE, T_{12} = BOD + 28gNPKMg + GE

Plate1: Screenhouse layout before treatment application

3.5 Treatment Application and Transplanting in the Screen House Experiment

Perforated poly bags were used for the screenhouse experiment. The bags were perforated at the bottom to prevent excess water from accumulating in the bags. A 5 kg of municipal dump soils collected at different locations was weighed into each polybag and arranged using a Completely Randomized Design (CRD) as seen in plate 2. The variety of Okra (*Abelmoschus esculentus)* used was NH Ae 47-4. and Garden egg *Solanum macrocarpon L.* (the white-green striped oval garden egg) were sourced from National Institute for Horticultural Research (NIHORT) Ibadan. Okra seeds were sown directly into the poly bag while garden egg seeds were raised on the nursery for 4 weeks and were transplanted singly by hand into each of the polybag according to treatment combinations as seen in plate 2. All the treatments were watered when necessary to obtain good emergence. Germination ranged between 4 to 7 days and germination count was taken after a week. Cultural practices such as weeding and pest control were carried out regularly throughout the period of the study.

Plate 2: Transplanting of Garden egg seedlings in the screen house

3. 6. Data Collection

Data were collected 3 weeks after planting (WAP) and at weekly intervals thereafter. The growth parameters at the vegetative stage were taken on a weekly basis for a period of three months as seen in plate 3 and 4. Growth parameters measured includes:

3.6.1. Plant height (cm) was measured on a weekly basis using a ruler in (cm) relative to the pot (from soil-based to the highest shoot).

3.6.2. Stem girth (cm) was measured at one inch from the soil surface with the aid of a vernier caliper.

3.6.3. Leaf area (cm^2) was calculated as the product of length from the base to the tip and the maximum width with a meter rule and the formula: Leaf area = Max. Length x Max. Width was used to determine the area of each leaf.

3.6.4. Number of leaves/plant was assessed by counting all the fully matured leaves on each plant.

3.6.5. Number of fruits: Data were taken manually for number of fruits harvested for Okras and Garden Egg, this was done by physical counting and total fruit yield was determined by cumulative total fruit harvested pertreatments using a weighing balance and total yields was expressed in t/ha.

3.6.6. Fruit weight

The various fruits harvested from each treatments were pulled to determine the total fruit weighed per treatment and was expressed as mean weight (gm) using a measuring scale.

3.6.7. Fruit yield/ha

The fruit yield per hectare was determined by extrapolating the fruit yield per net plot.

$$\text{Yield (t/ha)} = \frac{\text{Total Fruit Weight (g) x 10}}{\text{Land Area (m}^2\text{) x 1000}}$$

Plate 3: Data collection on growth parameters of Garden Egg plant

Plate 4: Data collection on growth parameters of Okra plant

3. 7. Statistical Analysis

Data collected were subjected to Analysis of Variance (ANOVA) using GENSTAT edition 2012 software. Treatments means were separated using Duncan multitude range test (DMRT) at 5% level of probability.

CHAPTER FOUR

4.0 RESULTS

4.1 Initial physical and chemical properties of the soil used from different dumpsites

The physical and chemical properties of the soils from different dumpsites used for the experiment are presented in Table 4.1. All the soils were of similar texture as evident in the textural classes of the soils from the different dumpsites locations and the control identified as Loamy sand. The soil pH of the dumpsites were slightly alkaline with pH values ranging from 7.28 to 7.56 across the dumpsites while the pH of the control (taken 200 m away from the dumpsite) was moderately acidic and ranged between 5.30 to 5.50.The organic carbon content ranged between 11.6 and 13.7g/kg. The total N observed from the dumpsites ranged between 0.065 to 0.199 %, with the controls having lower values as seen in Table 4.1. Generally, available P in soils from the dumpsites was relatively high. Benin Oluku Dumpsite (BOD) had the highest available P (125.33 mg/kg), followed by Benin Sapele Dumpsite (BSD) 64.47 mgkg^{-1} while Benin Agbor Dumpsite (BAD) had the lowest concentration of Avail. P (60.31 mg/kg) but was significantly ($P<0.05$) higher than the control with 3.59 for BADC, 4.32 for BODC, and 3.39 for BSDC.

The concentration of Ca from the dumpsite varied and ranged from 12.48 to 20.44 cmol/kg and was significantly higher than the control. Similar trend was observed on Mg, K and Na across the dumpsite compared with the control. The CEC content of the soils from the dumpsites ranged between 2.73 to 23.02 cmol/kg with Benin Agbor Dumpsite having the highest 23.02 cmol/kg compare to the other dumpsites relative to the control as seen in Table 4.1. In terms of fertility, the entire soils were high in Available phosphorus (>20 mg/kg) and low in exchangeable potassium (0.21- 0.30 cmol/kg) for Benin Oluku dumpsite and Benin Sapele dumpsite respectively, although in Benin Agbo dumpsite, exchangeable K was moderately low and ranged between (0.31- 0.60 cmol/kg).

Table 4.1: Initial soil physical and chemical properties of the soil used from different dumpsites

Sample locations	pH	O.C (g/kg)	Total N (%)	Aval. P (mg/kg)	Ca	Mg	K	Na	CEC cmol/kg	Sand g/kg	Silt g/kg	Clay g/kg	Textural class
					←	cmol/kg		→					
Benin Agbor Control	5.50	13.4	0.119	3.59	2.96	0.64	0.27	0.23	4.1	920	37	43	Loamy sand
Benin Agbor dumpsite	7.28	13.7	0.199	60.31**	20.44**	2.08	0.43	0.31	23.02**	950	31	19	Loamy sand
Benin Oluku control	5.50	17.3	0.122	4.32	7.44	0.80	0.15	0.11	8.57	950	27	23	Loamy sand
Benin Oluku dumpsite	7.54	11.8	0.16 2	125.33**	12.48**	1.92	0.29	0.18	14.6**	95.0	31	19	Loamy sand
Benin Sapele control	5.30	11.2	0.065	3.39	2.16	0.08	0.18	0.20	2.73	870	37	93	Loamy sand
Benin Sapele dumpsite	7.56	11.8	0.128	64.47**	16.64**	1.12	0.25	0.23	18.24**	950	31	19	Loamy sand

Total nitrogen was moderate and ranged between (0.16 – 0.20 %) in soils from Benin Agbor dumpsite and Oluku dumpsite, and were moderately low in Soils from Benin Sapele dumpsite. The fertility status of the soils from the different dumpsites revealed that soils from Agbor Road Bye Pass were high in potassium while soils from Oluku and Sapele Bye Pass dumpsites were high in phosphorus and nitrogen.

4.2 Concentration of heavy metals in the soils collected from different dumpsites

As shown in Table 4.2, the results for heavy metal concentrations in soil samples from various dumpsites showed slight variation. Fe content in the dumpsites ranged from 65.5 to 81.2 mg/kg. However, the highest Fe level 81.7 (mg/kg) was at Benin Agbor Dumpsite followed by Benin Oluku Dumpsite (72.5 mg/kg). The least content of Fe (65.5 mg/kg) was recorded in Benin Sapele Dumpsite. The heavy metal component of the dumpsite soils were significantly higher ($p<0.05$) than those of the control. The trend of occurrence of heavy metals in Benin Agbor Dumpsite revealed: Fe (81.7) mg/kg, Zn (62.3) mg/kg, Mn (39.5) mg/kg, Cu (15.0) mg/kg, Cr (10.67) mg/kg, Pb (10.65) mg/kg and Cd (7.03) mg/kg. While Benin Oluku Dumpsite had: Fe (72.5) mg/kg, Zn (54.4) mg/kg, Mn (34.8) mg/kg, Cu (17.7) mg/kg, Cr (12.60), Pb (9.45) mg/kg and Cd (6.24) mg/kg.

The least concentration of heavy metals was recorded in Benin Sapele Dumpsite soils which had Fe (65.5) mg/kg, Zn (49.1) mg/kg, Mn (31.4) mg/kg, Cu (16.0) mg/kg, Cr (11.38) mg/kg, Pb (8.54) mg/kg and Cd (5.64) mg/kg as seen in Table 4.2. Similar trend on the concentration of these heavy metals were observed in the control soils (taken 200m away from the dumpsite). The occurrence of these metals both in the dumpsite locations and the control areas indicates common sources of these metals which could be related to geochemical association between the metals.

Table 4.2: Concentration of heavy metals in the soils collected from different dumpsites

Dumpsites Locations	Fe	Mn	Zn	Cu	Cr	Cd	Pb
	mg/kg						
Benin Agbor Dumpsite	81.7	39.5	62.3	15.0	10.67	7.03	10.65
Benin Agbor control	51.4	23.2	46.1	20.0	14.20	5.28	8.05
Benin Oluku Dumpsite	72.5	34.8	54.4	17.7	12.60	6.24	9.45
Benin Oluku control	50.5	21.2	37.9	21.4	5.78	2.34	3.58
Benin Sapele Dumpsite	65.5	31.4	49.1	16.0	11.38	5.64	8.54
Benin Sapele control	50.3	20.3	38.0	12.4	8.79	4.35	5.26

4.3 Average yield and weight of harvested Okra per treatment

The average yields of harvested Okra fruits are presented in Table 4.3. Yield was enhanced by fertilizer application in all the dumpsite relative to the unfertilized and the control. The highest fruit yield (0.77t/h) of Okra was recorded from BOD+28gNPK+OK. This was closely followed by BSD+28g NPK+OK with (0.75t/ha) and BAD+28gNPK+OK (0.68t/ha) respectively. Dumpsite amended with fertilizer produced more fruits than the control plots even though treated plants had similar results in both dumpsites. Fruit yield of okra was similar in BAD+28gNPK+OK (0.68t/ha) and BOD+14 g NPK+OK (0.66t/ha) throughout the period of the harvest. The highest fruit of Okra may be due to the application of inorganic fertilizer to the dumpsites. This implies that, fertilizer influences the yield attributes of Okra. It was observed that, Okra fruits yields were lowest on the control soils taken 200 m from the dumpsite locations and other treatments as shown in Table 4.3. The fresh weight of harvested okra is presented in Table 4.4. Yield was enhanced by the addition of fertilizer to the dumpsite relative to the unfertilized and the control. It was observed that the highest weight of okra fruit was recorded in treatments BAD+28gNPK, BOD+28gNPK and BSD+28gNPK (21.5 gm, 15.8 gm and 15.1 gm), followed by BAD+14gNPK, and BOD+14gNPK (14.8 gm and 13.2gm) respectively and the lowest value of fruit weight was observed for the control treatments BADC, BSDC, BODC (12.2 gm, 10.5gm and 10.1gm respectively). There was no distinct pattern in the fresh weight of harvested Okra across the dumpsite and the control in Table 4.4. This may be due to the deformed fruits that influence the fresh weight of okra at harvested.

Table 4.3: Average yield of harvested Okra fruit

Treatment I.D	Yield of Okra per plant for each treatment (t/ha)						
	1st Harvest	2nd harvest	3rd Harvest	4th Harvest	5th Harvest	6th Harvest	Average
T_1 = BAD Control	0.18b	0.27ab	0.36ab	0.45ab	0.45ab	0.54b	0.37ab
T_2 = BAD+OK	0.17b	0.17c	0.36ab	0.45ab	0.54b	0.71a	0.31ab
T_3=BAD+14gNPK +OK	0.27ab	0.36b	0.54b	0.71a	0.60b	0.89a	0.59a
T_4= BAD+28gNPK+OK	0.45a	0.71a	0.80a	0.89a	0.87a	0.56b	0.68a
T_5 = BSD Control	0.09b	0.17c	0.27ab	0.45ab	0.36ab	0.27ab	0.27ab
T_6 = BSD+OK	0.09b	0.27ab	0.27ab	0.36ab	0.27ab	0.17ab	0.24ab
T_7 =BSD+14g NPK+OK	0.27ab	0.54b	0.45b	0.71a	0.61b	0.76a	0.59a
T_8 =BSD+28g NPK+OK	0.54a	0.71a	0.89a	0.77a	0.75a	0.84a	0.75a
T_9 = BOD Control	0.09b	0.27ab	0.36ab	0.45ab	0.36ab	0.17ab	0.28ab
T_{10} = BOD+OK	0.17b	0.45b	0.54b	0.63b	0.80a	0.83a	0.53b
T_{11}=BOD+14gNPK+OK	0.36ab	0.45b	0.71a	0.80a	0.89a	0.79a	0.66a
T_{12}=BOD+28gNPK+OK	0.45a	0.63a	0.89a	0.76a	0.89a	0.99a	0.77a

NPK=inorganic fertilizer (12:12:17), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

Table 4.4: Average weight of harvested Okra fruit

Treatment I.D	Weight of Okra fruits at Harvest (gm)						
	1st Harvest	2nd harvest	3rd Harvest	4th Harvest	5th Harvest	6th Harvest	Mean
T_1 = BAD Control	15.3b	6.6abc	9.3bc	12.6ab	14.2a	9.3abc	12.2c
T_2 = BAD+OK	10.5ab	9.6abc	13.3c	10.2c	15.2a	14.9a	12.3c
T_3 = BAD+14g NPK +OK	12.2ab	24.7a	15.6ab	13.8ab	12.1b	10.1b	14.8b
T_4 = BAD+28gNPK+OK	23.5a	25.3a	33.3a	27.3a	9.5ab	10.1b	21.5a
T_5 = BSD Control	8.7c	11.3bc	11.8abc	13.5ab	7.4ab	10.3b	10.5b
T_6 = BSD+OK	8.3c	20.5b	11.2abc	10.0c	8.1ab	10.8b	11.5ab
T_7 = BSD+14g NPK+OK	10.3ab	12.6bc	14.8ab	11.6c	10.1ab	13.5a	12.2c
T_8 = BSD+28g NPK+OK	10.7ab	14.5ab	23.1b	13.8ab	16.2a	12.3a	15.1b
T_9 = BOD Control	7.6c	8.4abc	10.4abc	10.5c	11.4b	10.5b	10.1ab
T_{10} = BOD+OK	8.2c	17.6ab	8.5bc	9.4abc	10.6b	11.3b	10.9ab
T_{11} =BOD+14 g NPK+OK	11.6ab	12.7bc	13.5c	13.9ab	12.8b	14.6a	13.2c
T_{12} = BOD+28gNPK +OK	13.1b	21.4b	15.8ab	16.6b	14.8a	12.9a	15.8b

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

4.4 Fresh weight and Yield of Garden Egg fruit at harvest

The average yield of garden egg fruit is presented in Table 4.5. The result showed that the highest yield of Garden egg (0.49 t/ha) was observed on BOD+28gNPK. This was closely followed by BSD+28gNPK (0.47 t/ha) and BAD+28gNPK (0.43 t/ha). Generally, garden egg fruit yields increased with the increasing rate of mineral fertilizer to the dumpsites. Treatments BAD+14gNPK, BSD+14gNPK and BOD+14gNPK do not have a significant different mean on the yield of garden egg in all the dumpsites. However, there was no significant different in the yield value of garden egg fruits across the dumpsites without fertilizer and the control in Table 4.5.

The fresh weight of harvested Garden egg fruit is presented in Table 4.6. It was observed that the highest weight of garden egg fruit was recorded in the fertilizer treated plants which differ from the quantity applied. Treatments BSD+28gNPK had the highest fruit weight (44.6 kg/ha) followed by BOD+28gNPK (34.8 kg/ha) and BAD+28gNPK (31.3 kg/ha). However, weight of garden egg were relatively low on BAD+14gNPK, (17.4 kg/ha), BSD+14gNPK (31.5 kg/ha) and BOD+14gNPK (23.4 kg/ha) but were significantly lower than the control in Table 4.6. There was a significant variation on the fruit weight of garden egg among the dumpsites. The low weight of garden egg was observed on the control treatment.

Table 4.5: Yield of Garden Egg fruit at harvest

Treatment I.D	Yield of Garden egg per plant for each treatment (t/ha)						
	1st Harvest	2nd harvest	3rd Harvest	4th Harvest	5th Harvest	6th Harvest	mean
T_1 = BAD Control	0.21b	0.3b	0.32ab	0.18bc	0.33ab	0.34bc	0.28ab
T_2 = BAD+GE	0.28a	0.32b	0.26c	0.35ab	0.38ab	0.37c	0.33ab
T_3 = BAD+14g NPK +GE	0.25b	0.32b	0.36ab	0.41b	0.42b	0.45ab	0.37b
T_4 = BAD+28gNPK+GE	0.31a	0.42a	0.37ab	0.47b	0.49b	0.53b	0.43a
T_5 = BSD Control	0.23b	0.27ab	0.29c	0.34ab	0.37ab	0.42ab	0.27ab
T_6 = BSD+GE	0.17ab	0.29b	0.31ab	018bc	0.50a	0.16abc	0.27ab
T_7 = BSD+14g NPK+GE	0.23b	0.41a	0.53a	0.43b	0.46b	0.28bc	0.39b
T_8 = BSD+28g NPK+GE	0.33a	0.44a	0.57a	0.46b	0.49b	0.53b	0.47a
T_9 = BOD Control	0.20b	0.24ab	0.33ab	0.23c	0.36ab	0.41ab	0.31ab
T_{10} = BOD+GE	0.14c	0.18ab	0.21c	0.26c	0.33ab	0.37c	0.25ab
T_{11} = BOD+14g NPK+GE	0.23b	0.26b	0.36ab	0.40b	0.36ab	0.48ab	0.34b
T_{12} = BOD+28gNPK +GE	0.36a	0.38a	0.43b	0.57a	0.47b	0.87a	0.49a

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

Table 4.6: Fruit weight of Garden egg at harvest

Treatment I.D	Fruit weight of Garden egg at harvest (kg/ha)						
	1st Harvest	2nd harvest	3rd Harvest	4th Harvest	5th Harvest	6th Harvest	Mean
T_1 = BAD Control	10.9c	12.1ab	13.8c	12.3c	11.7c	10.1abc	11.8abc
T_2 = BAD+GE	8.4bc	9.5abc	10.2bc	10.4abc	11.3c	11.2abc	10.2bc
T_3= BAD+14gNPK+GE	8.1bc	10.0abc	11.6bc	41.7b	12.6c	20.5ab	17.4c
T_4= BAD+28gNPK+GE	15.6ab	14.8b	24.5ab	50.8a	45.6a	36.5b	31.3b
T_5 = BSD Control	6.8abc	10.2ac	11.4bc	12.6c	13.9c	13.8c	11.5abc
T_6 = BSD+GE	8.0bc	9.5abc	10.0bc	12.6c	25.7ab	10.3abc	12.7abc
T_7 =BSD+14g NPK+GE	44.1a	25.1a	35.8b	39.6b	35.1b	9.5bc	31.5b
T_8 =BSD+28g NPK+GE	45.3a	26.5a	73.9a	45.3b	40.8a	35.8b	44.6a
T_9 = BOD Control	27.3b	12.5ab	11.6bc	7.1bc	8.9bc	6.3bc	12.3abc
T_{10} = BOD+0gNPK+GE	10.3c	12.5ab	11.3bc	10.9abc	10.3bc	8.8bc	10.7bc
T_{11}=BOD+14gNPK+GE	10.9c	15.3b	25.1ab	35.4ab	31.2b	25.8ab	23.4ab
T_{12}=BOD+28gNPK+GE	25.6b	25.8a	30.2b	35.2ab	47.5a	44.3a	34.8b

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

4.5 Effects of treatments on the growth parameters of Okra

4.5.1 Number of leaves

Average number of leaves per plant of the treatments at different periods is given in Table 4.7. The result showed that there was a significant difference ($P<0.05$) among the treatments due to the application of different fertilizer rates to the dumpsites. It was observed that the highest number of leaves per plant was recorded on BOD+28gNPK (10.48), BSD+28gNPK (10.21) and BAD+28gNPK (10.0). This was followed by BAD+14gNPK (8.10), BOD+14gNPK (7.92) and BSD+14gNPK (7.68) respectively throughout the growth period. The significant lowest number of leaves per plant was recorded in the control treatments as seen in Table 4.7.

4.5.2 Plant height of Okra

The effect of treatments on plant height of Okra is presented in Table 4.8. Results revealed that there was a significant ($p<0.05$) differences among the treatments on the plant height throughout the growth period. Highest plant height (68.22 cm) was observed on dumpsite soils amended with fertilizer BSD+ 48gNPK, BAD+48gNPK (63.76 cm) and BOD+ 48gNPK (62.89 cm) respectively. Followed by BSD+ 14gNPK (56.10 cm), BOD+ 14gNPK (52.24 cm). The lowest performance was showed where no fertilizer was added as shown in Table 4.8.

4.5.3 Stem girth of Okra

Data on the effects of treatments on Okra stem girth are presented in Table 4.9. The stem girth significantly differed ($P<0.05$) among the treatments. Highest stem girth 4.82, 4.75 and 4.57 cm were observed on dumpsites soil amended with fertilizer, BOD+ 48gNPK, BAD+ 48gNPK and BSD+ 48gNPK respectively. It was followed by BAD+ 14gNPK (3.62 cm), BSD+ 14gNPK (3.18 cm) and BOD+ 14gNPK (2.88 cm). While the minimum stem girth was recorded on dumpsite soil where no fertilizer was added and were at the control as shown in Table 4.9.

4.5.4 Leaf area of Okra

The effect of treatments on the leaf area of Okra is shown in Table 4.10. Leaf area differs significantly under NPK fertilizer application, sole dumpsite and the control throughout the growth period. It was observed that the highest mean value of the leaf area was observed on treatments BSD+ 48gNPK (19.76 m^2), BAD+ 48gNPK (16.13 m^2) and BOD+ 14gNPK which gave 15.22 m^2. In addition, the leaf area increased with increasing rate of NPK fertilizer. However, leaf area was significantly lower on sole dumpsite compared to the control as shown in Table 4.10.

Table 4.7: Effects of treatments on number of leaves of Okra

Treatments I.D		Weeks after Planting (WAP)								Mean
		W1	W2	W3	W4	W5	W6	W7	W8	
T_1	BAD control	2.34ab	4.37a	5.39ab	7.46a	8.34a	9.38ab	10.43ab	11.43ab	5.96ab
T_2	BAD + 0 g NPK	3.44a	4.35a	5.26ab	7.45a	9.14a	9.48ab	10.33ab	10.24ab	7.46b
T_3	BAD + 14 g NPK	3.51a	5.45a	5.43ab	6.19a	9.38a	10.12ab	12.31ab	12.41ab	8.10b
T_4	BAD + 28 g NPK	4.82a	5.66a	7.88a	8.23a	10.12a	12.68a	14.52a	15.32a	10.0a
T_5	BSD control	2.13ab	3.67ab	4.39ab	5.13ab	7.75ab	9.24ab	10.33ab	12.05ab	6.84b
T_6	BSD + 0 g NPK	3.45a	3.89ab	4.25ab	5.56ab	7.47ab	9.96ab	10.23ab	10.41ab	6.90b
T_7	BSD + 14 g NPK	3.42a	4.23ab	5.34ab	6.23ab	8.45ab	10.23ab	10.39ab	13.12ab	7.68b
T8	BSD + 28 g NPK	4.63a	5.78a	7.82a	9.68a	11.25a	12.62a	14.15a	15.78a	10.21a
T_9	BOD control	2.43ab	3.54ab	4.84ab	6.31ab	7.23ab	9.32ab	10.43ab	11.28ab	6.92b
T_{10}	BOD + 0 g NPK	3.42ab	3.68ab	3.89ab	4.28b	4.73ab	5.69ab	6.18b	9.97ab	5.23ab
T_{11}	BOD + 14 g NPK	3.92ab	4.41ab	5.32ab	7.43ab	9.32ab	10.36ab	10.52ab	12.08ab	7.92b
T_{12}	BOD + 28 g NPK	4.96a	6.83a	7.92a	9.68a	11.46a	13.04a	14.34a	15.57a	10.48a

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17:), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

Table 4.8: Effects of treatments on plant height of Okra (cm)

Treatments I.D		Weeks after Planting (WAP)								
		W1	W2	W3	W4	W5	W6	W7	W8	Mean
T_1	BAD control	32.47ab	36.30ab	38.20ab	39.60ab	43.20ab	45.30a	47.47ab	48.67ab	41.40ab
T_2	BAD + 0 g NPK	28.33ab	28.93ab	30.90ab	34.83ab	38.47ab	40.83a	44.67ab	47.67ab	36.82ab
T_3	BAD + 14 g NPK	39.50ab	40.17ab	37.23ab	45.67ab	47.83ab	56.57a	56.90a	55.67ab	47.44b
T_4	BAD + 28 g NPK	51.00a	53.67a	56.67a	77.67a	75.57a	56.66a	66.17a	72.73a	63.76a
T_5	BSD control	33.03b	39.23ab	45.17ab	46.33ab	35.50b	46.93ab	47.17ab	45.67b	42.37ab
T_6	BSD + 0 g NPK	41.37ab	42.70ab	44.83ab	47.00ab	50.77ab	53.73ab	55.33ab	58.50ab	49.27b
T_7	BSD + 14 g NPK	45.10ab	47.93ab	51.77ab	55.47ab	58.40ab	61.00a	63.63ab	65.50ab	56.10b
T_8	BSD + 28 g NPK	55.50a	59.7a	67.27a	73.47a	73.17a	65.50a	74.83a	76.33a	68.22a
T_9	BOD control	46.10ab	54.03ab	55.17a	50.50a	56.00a	54.83a	48.63a	47.50a	51.59b
T_{10}	BOD + 0 g NPK	42.50ab	42.83ab	52.73a	73.47a	53.27a	44.50a	48.17a	45.00a	50.30b
T_{11}	BOD + 14 g NPK	38.40ab	46.90ab	53.33a	57.00a	59.27a	56.87a	55.53a	50.67a	52.24b
T_{12}	BOD + 28 g NPK	64.63a	74.03a	59.40a	59.43a	61.13a	61.13a	61.17a	62.17a	62.89a

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17:), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

Table 4.9: Effects of treatments on stem girth of Okra (cm)

		Weeks after planting (WAP)								
Treatments I.D		W1	W2	W3	W4	W5	W6	W7	W8	Mean
T_1	BAD control	1.52ab	1.71ab	2.12ab	2.81ab	3.25ab	3.46ab	3.83ab	3.76ab	2.80b
T_2	BAD + 0 g NPK	1.23ab	1.34ab	1.65ab	2.23ab	2.62ab	2.89ab	3.13ab	3.38ab	2.30b
T_3	BAD + 14 g NPK	2.39ab	2.41ab	2.63ab	3.71a	4.63a	4.69a	4.42ab	4.58a	3.62ab
T_4	BAD + 28 g NPK	3.34a	3.86a	3.96a	4.87a	5.08a	5.48a	5.59a	5.87a	4.75a
T_5	BSD control	1.40ab	1.86ab	1.91ab	2.45ab	2.69ab	2.75ab	3.06ab	3.28ab	2.42b
T_6	BSD + 0 g NPK	1.33ab	1.76ab	1.34ab	1.81ab	2.26ab	3.67ab	3.73ab	3.81ab	2.46ab
T_7	BSD + 14 g NPK	2.28ab	2.54ab	3.28a	3.45a	3.36ab	3.79ab	3.35ab	3.45ab	3.18ab
T_8	BSD + 28 g NPK	3.46a	3.75a	3.96a	4.28a	4.57a	5.18a	5.47a	5.93a	4.57a
T_9	BOD control	1.33ab	1.42ab	1.65ab	1.87ab	2.13ab	2.42ab	2.83ab	3.06ab	2.08b
T_{10}	BOD + 0 g NPK	1.34ab	1.56ab	1.73ab	1.82ab	2.03ab	2.36ab	2.65ab	2.74ab	2.02b
T_{11}	BOD + 14 g NPK	2.03ab	2.25ab	2.62ab	2.89ab	3.08ab	3.27ab	3.43ab	3.51ab	2.88ab
T_{12}	BOD + 28 g NPK	3.56a	3.89a	4.17a	4.64a	5.25a	5.52a	5.61a	5.93a	4.82a

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17:), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

Table 4.10: Effects of treatments on leaf area of the okra (m^2)

		Weeks after Planting (WAP)								
Treatments I.D		W1	W2	W3	W4	W5	W6	W7	W8	Mean
T_1	BAD control	2.26b	3.24b	4.23b	5.38b	8.04b	10.81ab	12.10b	14.72c	7.59c
T_2	BAD + 0 g NPK	3.10ab	5.34ab	8.10ab	11.30ab	12.54ab	16.74ab	19.07ab	21.9ab	12.26ab
T_3	BAD + 14 g NPK	4.83a	6.63ab	9.21ab	12.02ab	14.41ab	16.53ab	19.80ab	23.63a	13.38ab
T_4	BAD + 28 g NPK	5.84a	9.45a	12.20a	14.10a	17.64a	20.43a	23.33a	26.07a	16.13b
T_5	BSD control	2.83ab	4.31ab	8.93ab	10.44c	12.02ab	14.32b	15.30b	17.42b	10.9c
T_6	BSD + 0 g NPK	3.45a	6.90ab	7.05ab	12.38ab	14.63ab	16.47ab	19.22ab	21.73ab	12.72ab
T_7	BSD + 14 g NPK	3.78a	5.32ab	9.93ab	12.83ab	14.08ab	17.97ab	20.49ab	23.83ab	13.52ab
T_8	BSD + 28 g NPK	4.62a	8.94a	13.83a	17.45a	21.03a	24.38a	27.14a	35.16a	19.06a
T_9	BOD control	2.56ab	4.47ab	5.08b	8.42b	10.72ab	12.46b	15.18b	19.04b	9.74c
T_{10}	BOD + 0 g NPK	3.93ab	6.23a	8.05ab	11.61ab	14.43ab	17.04ab	21.09ab	23.84ab	13.27ab
T_{11}	BOD + 14 g NPK	4.24a	6.89a	10.10ab	14.8ab	17.38ab	20.06ab	23.05ab	25.28ab	15.22b
T_{12}	BOD + 28 g NPK	4.78a	9.03a	13.03a	18.7a	24.5a	26.94a	27.61a	33.45a	19.76a

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17:), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

4.6 Effects of treatments on the growth parameters of Garden egg

4.6.1 Number of leaves of garden egg

The effects of treatments on the leaf number of garden egg are presented in Table 4.11. Generally, the result showed that, addition of NPK fertilizer on the dumpsite has been shown to increase the number of leaves of garden egg. Result also revealed that, the highest number of leaves per treatments were recorded on BSD+ 48gNPK (29.9), followed by BSD+ 14gNPK (28.8). The least number of leaves was observed on BAD+ 48gNPK (26.5) compared to the control and the other treatments throughout the period of the experiment.

4.6.2 Plant height of garden egg

The effect of treatments on plant height of Garden egg is presented in Table 12. Result showed that the highest plant heights were observed on BAD+ 48gNPK and BOD+ 48gNPK with a mean value of (61.1 cm) and (61.83 cm) respectively. Treatment BAD+ 48gNPK gave the lowest plant height of (58.1 cm) but was significantly higher than BSD+ 14gNPK (48.6 cm), BAD+ 14gNPK (41.6 cm) and BOD+ 14gNPK (40.9 cm). The increase in the height of garden egg may be due to the addition of mineral fertilizer application. However, the lowest plant height was recorded on the control.

4.6.3 Stem girth of garden egg

The stem girth of the garden egg plant is presented in Table 13. The result showed a significant increase in the girth of the garden egg plant following the application of mineral fertilizer. Result revealed that the stem girth of garden egg was high at BSD+ 48gNPK (7.21 cm), this was followed by BOD+ 48gNPK (5.2 cm). However, stem girth of garden egg was lowest at BOD control (4.67 cm), BSD+ 14gNPK (4.51 cm) and BAD+ 14gNPK (3.9 cm), were significantly higher than the control.

4.6.4 Leaf area of garden egg

The effects of treatments on the leaf area of garden egg are presented in Table 14. Results of the study showed that effects of treatments were significant on the leaf area of garden egg. It was observed that Treatment BAD+48gNPK gave the highest (22.45 m^2) leaf area. This was closely followed by BSD+48gNPK (20.29 m^2). However, leaf area were statistically at par with each other and both were superior over the control BAD+0gNPK, BAD+14gNPK, BSD+0gNPK, BSD+14gNPK and BOD+48gNPK with a mean value of 15.49m^2, 16.63 m^2, 15.03 m^2 , 15.62 m^2 and 15.91 m^2 respectively. The lowest mean value of leaf area was recorded on the control.

Table 4.11: Effects of treatments on the number of leaves of Garden egg

Treatments (g)		Weeks after planting (WAP)								
		W1	W2	W3	W4	W5	W6	W7	W8	Mean
T_1	BAD control	10.67ab	12.00ab	11.67ab	18.67ab	11.67ab	19.33ab	22.08ab	23.89ab	16.24b
T_2	BAD + 0 NPK	10.00ab	14.00ab	17.33ab	18.00ab	17.33ab	22.00ab	23.21ab	25.86ab	18.46ab
T_3	BAD + 14 NPK	16.33a	21.00ab	21.33ab	26.33ab	27.33ab	55.67ab	35.01ab	48.13ab	19.14ab
T_4	BAD + 28 NPK	11.03ab	17.30ab	24.63a	23.92a	24.63a	34.79a	36.12a	40.09a	26.56a
T_5	BSD control	12.33ab	13.00ab	16.33ab	21.00ab	18.33ab	19.33ab	21.05ab	26.32ab	18.46ab
T_6	BSD + 0 NPK	12.00ab	11.00ab	21.00ab	24.67a	21.00ab	32.00a	33.83a	35.09ab	23.82ab
T_7	BSD + 14 NPK	12.33ab	21.67ab	26.33ab	30.67a	26.33ab	35.67a	38.63a	39.06a	28.83a
T_8	BSD + 28 NPK	23.67a	27.67a	24.68a	31.00a	33.00a	25.33ab	31.06a	43.04a	29.93a
T_9	BOD control	11.00a	13.00a	14.00ab	14.33ab	14.00ab	16.00ab	17.05ab	19.18ab	14.82b
T_{10}	BOD + 0 NPK	8.33a	9.33ab	13.00ab	15.00ab	13.00ab	15.00ab	18.05ab	21.04ab	14.09b
T_{11}	BOD + 14 NPK	13.94a	15.20a	18.44ab	23.64ab	18.48ab	25.36a	26.90a	33.64a	21.95ab
T_{12}	BOD + 28 NPK	10.67a	15.33a	22.67a	31.33a	22.67a	34.00a	37.14a	43.14a	27.11a

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17:), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

Table 4.12: Effects of treatments on plant height of Garden egg (cm)

	Treatments (g)	Weeks after planting (WAP)								
		W1	W2	W3	W4	W5	W6	W7	W8	Mean
T_1	BAD control	23.3ab	27.4ab	29.6ab	31.9ab	34.5ab	37.8ab	40.7ab	43.2ab	33.55ab
T_2	BAD + 0 NPK	26.3ab	27.2ab	32.5ab	37.1ab	38.7ab	42.5ab	44.5ab	47.1ab	36.98ab
T_3	BAD + 14 NPK	34.7a	35.6ab	37.2ab	40.5ab	43.6ab	44.5ab	45.8ab	50.9ab	41.6ab
T_4	BAD + 28 NPK	45.1a	50.4a	53.2a	62.1a	66.5a	68.1a	72.5a	75.3a	61.65a
T_5	BSD control	21.6ab	24.9ab	27.5ab	30.5ab	33.4ab	36.5abc	39.4ab	41.5ab	31.91ab
T_6	BSD + 0 NPK	26.1ab	28.5ab	32.6ab	37.5ab	38.4ab	44.3abc	49.4ab	51.2ab	38.5ab
T_7	BSD + 14 NPK	32.8ab	41.2a	44.3a	48.4a	54.5a	53.5ab	54.6ab	59.5ab	48.6ab
T_8	BSD + 28 NPK	48.2a	52.2a	54.3a	56.5a	58.4a	60.5a	65.6a	69.1a	58.1b
T_9	BOD control	22.3ab	29.4ab	32.5ab	34.4ab	36.7ab	38.3ab	42.6ab	45.4ab	35.2ab
T_{10}	BOD + 0 NPK	24.1ab	27.6ab	30.6ab	36.1ab	39.5ab	44.3ab	46.8ab	49.5ab	37.31ab\
T_{11}	BOD + 14 NPK	33.9ab	37.1ab	38.5ab	37.1ab	40.5ab	43.5ab	47.6ab	49.3ab	40.9ab3
T_{12}	BOD + 28 NPK	42.3a	50.5a	60.1a	62.4a	69.2a	71.5a	68.2a	70.5a	61.83a

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17:), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

Table 4.13: **Effects of treatments on stem girth of garden egg (cm)**

	Treatments (g)	Weeks after planting (WAP)								
		W1	W2	W3	W4	W5	W6	W7	W8	Mean
T_1	BAD control	1.9ab	2.4a	2.9a	3.4a	3.5a	3.6a	4.1ab	4.4a	3.27b
T_2	BAD + 0 NPK	2.3ab	2.5a	2.7a	2.9a	3.2a	3.4a	3.6ab	3.8a	3.05ab
T_3	BAD + 14 NPK	3.3a	3.4a	3.6a	3.6a	4.1a	4.3a	4.4ab	4.5a	3.9b
T_4	BAD + 28 NPK	3.6a	3.7a	3.8a	4.2a	4.5a	4.7a	4.9a	5.3a	4.34b
T_5	BSD control	2.5a	2.7ab	2.4ab	3.1a	2.5ab	2.7ab	2.9ab	3.3ab	2.76ab
T_6	BSD + 0 NPK	1.5ab	1.7ab	1.8ab	2.3ab	2.6ab	2.9ab	3.2ab	3.4ab	2.43ab
T_7	BSD + 14 NPK	3.6a	3.8a	3.9a	4.3a	4.7a	4.9a	5.3a	5.6a	4.51b
T_8	BSD + 28 NPK	2.3ab	3.1ab	3.4ab	3.5a	3.8a	4.4ab	4.5a	4.8a	7.21a
T_9	BOD control	3.1a	3.7a	3.9a	4.5a	4.8a	5.3a	5.7a	6.4a	4.67b
T_{10}	BOD + 0 NPK	1.6ab	1.8ab	2.3ab	2.4ab	2.8ab	3.3ab	3.5a	3.7ab	2.67ab
T_{11}	BOD + 14 NPK	2.4a	3.3a	3.4ab	3.9a	4.3a	4.5a	4.6a	4.8a	3.90b
T_{12}	BOD + 28 NPK	2.7a	2.8a	3.2ab	3.5a	3.6ab	3.7a	4.2a	4.4ab	5.31b

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17:), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

Table 4.14: **Effects of treatments on leaf area of garden egg (m^2)**

Treatments (g)		Weeks after planting (WAP)								
		W1	W2	W3	W4	W5	W6	W7	W8	Mean
T_1	BAD control	2.51ab	5.70ab	6.49b	10.32ab	14.83b	16.30	23.51 b	25.12b	13.09ab
T_2	BAD + 0 NPK	2.73ab	7.40ab	8.34ab	13.25ab	17.42b	21.46b	25.92b	27.43b	15.49b
T_3	BAD + 14 NPK	3.36ab	8.24ab	10.10ab	13.48ab	15.63b	24.53b	26.34b	31.42a	16.63b
T_4	BAD + 28 NPK	5.28a	10.35a	15.50a	20.9a	24.6 a	30.31a	35.23a	37.46a	22.45a
T_5	BSD control	2.38ab	4.63b	6.06b	10.43ab	15.34b	17.47ab	19.5ab	22.43ab	12.28ab
T_6	BSD + 0 NPK	3.04ab	5.32b	7.46b	11.68ab	16.49b	22.05b	24.05b	27.18b	15.03b
T_7	BSD + 14 NPK	3.94ab	6.48ab	9.23ab	12.48ab	14.62b	21.09b	24.42b	32.71a	15.62b
T_8	BSD + 28 NPK	5.36a	9.79a	11.64a	15.81b	20.53a	27.45a	33.47a	38.28a	20.29a
T_9	BOD control	2.84ab	3.08b	5.35b	7.88c	9.20ab	11.34ab	13.03ab	15.72ab	8.55ab
T_{10}	BOD + 0 NPK	3.26ab	5.72ab	7.82ab	8.04c	10.31ab	12.44ab	14.39ab	17.42ab	9.92ab
T_{11}	BOD + 14 NPK	3.43ab	6.05ab	8.37ab	9.23c	10.04ab	11.32ab	18.47ab	22.58b	11.18ab
T_{12}	BOD + 28 NPK	5.68 a	8.85a	10.65a	12.09ab	15.58b	20.63b	24.52b	29.31b	15.91b

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPK= inorganic fertilizer (12:12:17:), Benin Agbor Dumpsite (BAD), Benin Sapele Dumpsite (BSD), Benin Oluku Dumpsite (BOD) and the Control.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Soil physical and chemical properties

The results of the soil physical, chemical and heavy metal concentration of different dumpsite show that the textural class of the selected dumpsite soils was predominantly loamy sand in Benin Agbor, Benin Sapele, Benin Oluku dump-site and the Control. The presence of sand particles in the dump-site location could be attributed to water erosion which transports sandy materials and deposits them at the dump-site. Obianefo *et al*. (2017) noted that the decomposition of municipal waste of soil micro-organisms had significant impacts on the texture of the underlying soils. Soil reaction (pH) is an indication of most physical, chemical and biological processes within soils system (Prareena and Rao, 2016). The pH of the various dumpsites was slightly alkaline and ranged from 7.28 to 7.56. The highest pH (7.56) was recorded at Benin Sapele Dumpsite followed by Benin Oluku Dumpsite (7.54). Benin Agbor Dumpsite recorded the least pH (7.28). This indicates that the soils at the various dumpsites were neutral to slightly alkaline. This observation corroborates with earlier findings by Obasi *et al*. (2012) who reported that, the pH values of dumpsite are mostly alkaline in nature due to the abundance of alkali-earth metals/liming materials and activities of soil microorganism. This may be due to the precipitation of metal ions as insoluble hydroxides at high pH values (7.6-8.3). The control location (taken 200 m away from the dumpsite) was slightly acidic with a pH range of 5.30 to 5. 50. However, the slight acidity values observed might be due to the dumping of acidic waste materials like batteries on the dumpsite. Metal solubility generally decreases with increasing pH (Gould *et al*., 1989). Organic carbon (O.C) content of the dumpsite ranged from 1.16 to 1.37 were significantly different ($p < 0.05$) from each other; the high content of O.C 1.37mg/kg observed at Benin Agbor Dumpsite may be attributed to the addition of waste materials such as tree branches, household waste, sawdust, and increased microbial activities as compared to the control location (Ndukwu, *et al*, 2008).The nitrogen (N) content of the dumpsites showed significant differences (p <0.05) among the various locations. Soil nitrogen ranged from 1.28 to 1.99 g/kg within the dumpsites. The highest total N value of 1.99g/kg was recorded at Benin-Agbor Dumpsite, followed by Benin-Oluku Dumpsite 1.62g/kg while the least was recorded in Benin-Sapele Dumpsite 1.28g/kg. The high N content recorded may be due to the addition of ash from the burning at the dump-site as opposed to no burning at the control locations. This is consistence with Ayeni *et al*. (2008) who noted that increased total N observed on dumpsite is usually due to the application of ash-based products. This suggests that soils sampled at the dump-site location were high in total N content relative to total N content recorded at the control locations. Data analysis showed that available phosphorus (P) levels followed similar trends as the soil pH above; Benin-Oluku Dumpsite had the highest 125.3 mg/kg P followed by Benin-Sapele Dumpsite (64.47 mg/kg) while the least (60.31 mg/kg) P value was recorded in Benin-Agbor Dumpsite. The levels of P content observed at the various dumpsites could be associated with the nutritive content of the waste since majority of the municipal wastes are household and agricultural wastes. The Potassium content at the various dumpsite locations showed significant differences (P<0.05) among dumpsite and followed similar trends to that of available P and ranked as Benin-Agbor Dumpsite (0.43 mg/kg)> Benin-Oluku Dumpsite (0.29 mg/kg)> Benin-Sapele Dumpsite (0.25 mg/kg). This implies that K levels of the dump-site are rich for the cultivation of agricultural crops. Generally, the control locations had low K values. The highest exchangeable Mg concentrations were observed at the dump-site location with Benin-Agbor Dumpsite having 20.44mg/kg followed by Benin-Sapele Dumpsite 16.64 mg/kg and 12.48 mg/kg for Benin-Oluku dumpsite respectively. Similar trend was observed on Ca content of the various dumpsite. However low values of Mg and Ca were both recorded in the control location. This finding conforms to the works of Ayeni *et al*. (2008) who reported similar increased values of Mg and Ca at a dumpsite in Nigeria. The highest exchangeable bases at the dump-site location resulted in the high pH, suggesting the ameliorative effects of exchangeable bases on soil pH. The relatively high amount of exchangeable bases at the dumpsite is an indication of the nutritive content and increased microbial activities.

5.2 Heavy metal concentrations

Results of the concentration of heavy metals from the dump-sites indicated that there is spatial variability in the concentration of each individual heavy metal among the study locations. This depicted that the concentration of Fe, Mn, Zn, Cr, Cd and Pb are higher in the study locations relative to the control except Cu which was low in Benin Agbor Dump-site and Benin Oluku Dump-site but was significantly higher in Benin Sapele Dump-site than the control. Similar result had earlier been reported by Owode *et al*, (2008). However, the result of the heavy metal observed in this study was below the permissible limit of 100 mg/kg (NEPM, 1999). This may be attributed to the industrial and domestic waste deposited in the dump-site location which increase the heavy metals load into the soil. This observation corroborates earlier findings by Muchuweti *et al*. (2006) and Wuana and Okieimen (2011) who reported that causes of heavy metals in soil could be attributed to discharge of industrial and domestic waste, sewage sludge or effluent. The concentration of Fe ranged from 81.7 to 65.5 mg/kg in the different dumpsite evaluated, However, in each dumpsite location Fe concentration were high (81.7 mg/kg) in Benin-Agbor Dump-site compared to the control likewise the other location. The values observed in this study were lower compared to the NYSDEC (2007) limit of 200 mg/kg and the maximum tolerable levels proposed for agricultural soil, 90-400 mg/kg set by WHO, (1993) and US EPA (2002). This however conformed to the works of Umoh and Etim (2013) for soils from dumpsites within Ikot-Ekpene in Akwa-Ibom State, Nigeria. The levels of Cr in the dump soils varied between 10.67 and 12.60

mg/kg and was highest in Benin-Oluku Dump-site relative to the control. Comparison of Cr values in the three dump-sites with respect to control revealed that Cr content was higher in the dump-sites soil. This may be due to the waste consisted of lead-chromium batteries, discarded plastic materials and empty paint containers. However, the Chromium content of the dump-site was lower than the critical permissible level of 50 mg/kg for soils recommended for agriculture (EC, 1986 and MAFF, 1992). The concentration of Pb in the soils from the dump-sites ranged from 8.54 to 10.65 mg/kg. Low content of lead was recorded in the control. The presence of lead in the dump-site locations could be as a result of dry cell batteries, runoff of wastes, sewage effluents and atmospheric depositions. Although, the concentrations of these metals were below, the permissible level, their accumulation in the soils over time could be detrimental to plants and humans.

5.3. Yield of Okra and Garden Egg

The average yields of harvested Okra were enhanced by fertilizer application in all the dumpsite relative to the unfertilized and the control. This observation corroborates the findings of Khalid *et al*. (2014) and Adekiya *et al*. (2018) who reported that high level of nitrogen, phosphorus and potassium heightened garden egg plants due to the initial nutrient release from the inorganic fertilizer which ensure consistent supply of nutrient for crop growth and fruiting (Fageria, 2014). The highest fruit yield (0.77t/h) of Okra was recorded from Benin-Oluku Dumpsite with 28gNPK. This was closely followed by Benin-Sapele Dumpsite with 28gNPK with (0.75t/ha) and Benin-Agbor Dumpsite with 28g NPK (0.68t/ha) respectively. Dumpsite amended with fertilizer produced more fruits than the control plots even though treated plants had similar results in both dumpsites. Fruit yield of okra was similar in BAD+ 48gNPK (0.68t/ha) and BOD+ 14gNPK (0.66t/ha) throughout the period of the harvest. The highest yield of Okra may be due to the application of inorganic fertilizer to the dumpsites. This implies that, fertilizer influences the yield attributes of Okra. This observation is consistent with (Adekiya *et al.*, 2018) who noted that the initial nutrient release from the inorganic fertilizer ensure consistent supply of nutrient for crop growth and fruiting. This observation is consistent with Oshunsanya (2010) who noted that okra yield difference is attributed to the fertility status of the soil. It was observed that, Okra fruits yields were lowest on the control soils taken 200 m from the dumpsite locations and other treatments The fresh weight of harvested okra was enhanced by the addition of fertilizer to the dumpsite relative to the unfertilized. The highest weight of okra fruit was recorded in treatments BAD+ 48gNPK, BOD+ 48gNPK and BSD+ 48gNPK (21.5 gm, 15.8 gm and 15.1 gm), followed by BAD+ 14gNPK, and BOD+ 14gNPK (14.8 gm and 13.2gm) respectively and the lowest value of fruit weight was observed for the control treatments BADC, BSDC, and BODC (12.2 gm, 10.5gm and 10.1gm respectively). There was no distinct pattern in the fresh weight of harvested Okra across the dumpsite and the control. This may be due to the deformed fruits that influence the fresh weight of okra at harvest. This observation corroborates with the work of Pitan and Ekoja (2012) who stated that the weight of the fruit decreased due to deformation associated by attack of insect pest. The highest (0.49 t/ha) average yield of Garden egg was observed on BOD+ 48gNPK. This was closely followed by BSD+ 48gNPK (0.47 t/ha) and BAD+ 48gNPK (0.43 t/ha). Generally, garden egg fruit yields increased with the increasing rate of mineral fertilizer to the dumpsites. This observation corroborates the findings of Khalid *et al*., (2014) who reported that high level of nitrogen, phosphorus and potassium heightened garden egg plants. The highest weight of garden egg fruit was recorded in the fertilizer treated plants which differ from the quantity applied. The yield of garden egg in this trial was low, contrasting Obeng-Ofori (2007) but supported Oviasogie and Oshodi, (2007) and Okonkwo *et al*. (2013). Treatments BSD+ 48gNPK had the highest fruit weight of garden egg (44.6 kg/ha) followed by BOD+ 48gNPK (34.8 kg/ha) and BAD+ 48gNPK (31.3 kg/ha). However, weight of garden egg were relatively low on BAD+ 14gNPK (17.4 kg/ha), BSD+ 14gNPK (31.5 $kgha^{-1}$) and BOD+ 14gNPK (23.4 $kgha^{-1}$) respectively compared to the control. The low weigh of garden egg may be due to deformation of garden egg fruits and insect attack that bore holes on the fruits.

5.4. Effects of treatments on the growth parameters of Okra and Garden

There was a significant difference ($P<0.05$) among the treatments due to the application of different fertilizer rates to the dumpsites on the number of leaves. The highest number of leaves per plant was recorded on BOD+ 48gNPK (10.48), BSD+ 48gNPK (10.21) and BAD+ 48gNPK (10.0), followed by BAD+ 14gNPK (8.10), BOD+ 14gNPK (7.92) and BSD+ 14gNPK (7.68) respectively throughout the growth period. The significant lowest number of leaves per plant was recorded in the control. Similar trend were observed on plant height. However, the highest plant height (68.22 cm) was observed on dumpsite soils amended with fertilizer BSD+ 48gNPK, BAD+ 48gNPK (63.76 cm) and BOD+ 48gNPK (62.89 cm) respectively, followed by BSD+ 14gNPK (56.10 cm) and BOD+ 14gNPK (52.24 cm). It was confirmed that, increasing rate of fertilizer caused comparable effects on plant height. This suggested that rapid mineralization of inorganic fertilizer could have led to its high vegetative growth performance in plant height. The increases in growth might be due to the rapid mineralization of nutrient element present in the fertilizer addition to the dumpsites. The lowest performance of garden egg was showed where no fertilizer was added. Highest stem girth of garden egg 4.82, 4.75 and 4.57 cm were observed on dumpsites soil amended with fertilizer, BOD+ 48gNPK, BAD+ 48gNPK and BSD+ 48gNPK respectively which was followed by BAD+ 14gNPK (3.62 cm), BDD+ 14gNPK (3.18 cm) and BOD+ 14gNPK (2.88 cm). The least stem girth was recorded on dumpsite soil where no fertilizer was added and was at pal with the control. This may be due to the low nutrient content of the dumpsite. Similar trend was also observed on the leaf area of garden egg plant. The highest mean value of the leaf area was observed on treatments BSD+ 48gNPK (19.76 m^2), BAD+ 48gNPK (16.13 m^2) and BOD+ 14gNPK which gave 15.22 m^2. In addition, the leaf area increased with increasing rate of NPK fertilizer. This observation is consistent with the findings of Adekiya *et al*., (2018) who stated that nitrogen is needed by plants during their vegetative growth period, and also manifest on the formation of wider and longer leaves. Also, Yamagata and Otami (1996), reported that mineral fertilizer improved soil fertility and provide a better nutrient supply to the soil. Garden egg plant growth and physiology improved with the application of increasing levels of NPK fertilizer, this may be due to mineral nutrient addition to the dumpsites which enhanced the activities of soil microorganisms resulting in more availability of nutrients. This observation is consistent with the results obtained by Yamagata and Otami (1996), who reported that mineral fertilizer improved soil fertility and provide better nutrient supply. The decline in the growth parameters as observed with the control may be due to poor soil nutrients status to support the growth of plants.

CONCLUSION

The findings of this study demonstrate that the heavy metal concentrations detected in the soils collected from the investigated dumpsites were generally low and remained below established critical limits for agricultural soils. This suggests that, under controlled conditions, such soils do not pose immediate toxicological risks to okra and garden egg plants. Variations in heavy metal content among dumpsites, however, indicate spatial heterogeneity, emphasizing the importance of site-specific assessment before agricultural utilization.

The application of NPK fertilizer significantly improved the growth parameters of both okra and garden egg, including plant height, leaf development, and overall vigor. This indicates that while dumpsite soils may contain residual nutrients and organic matter, supplemental inorganic fertilization enhances nutrient availability and supports optimal crop performance. The combined use of moderately safe dumpsite soils and balanced fertilizer application therefore presents a potential strategy for improving vegetable production, particularly in resource-constrained environments.

The study confirms that dumpsite soils when carefully assessed and properly managed can serve as supplementary agricultural soils for okra and garden egg production. However, environmental safety and food security considerations must remain paramount.

Recommendations

It is recommended that:

1. All dumpsite soils intended for agricultural use should undergo comprehensive physical and chemical and heavy metal analysis to ensure concentrations remain below permissible limits established by regulatory standards.

2. Only dumpsites with consistently low heavy metal concentrations should be considered for vegetable production. Areas with elevated toxicity levels should be avoided to prevent bioaccumulation in edible plant parts.
3. Dumpsite soils should be used in conjunction with appropriate rates of NPK fertilizer to enhance nutrient balance and maximize crop yield. Organic amendments may also be incorporated to improve soil structure and microbial activity.
4. Continuous monitoring of soil and plant tissue heavy metal content is recommended to prevent long-term accumulation and potential health risks to consumers.
5. Farmers should adopt safe agronomic practices, including proper irrigation management, crop rotation, and controlled fertilizer application, to minimize environmental risks.
6. Agricultural extension services should provide guidance on safe dumpsite soil utilization, and environmental regulatory agencies should enforce standards to protect public health.

By implementing these recommendations, okra and garden egg production can be sustainably enhanced while minimizing ecological and health risks associated with dumpsite soil usage.

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APPENDIX

Pate 5: Mature Garden Egg Plant

Plate 6: Harvested and Processed Garden Egg Plant

Plate 7: Experimental Layout of the Garden Egg Plant

Plate 8: Experimental Layout of the Okra Plant

Plate 9: Fresh Okra fruits

Plate 10: Mature Fruit-Bearing Garden Egg Plant

Plate 11: Harvested and Processed Okra Plant